Claims

[c1] 1.A diffuser augmented with fluidic actuation, the diffuser comprising:

a longitudinal axis;

a diffuser inlet having a width W;

a diverging section having a diffuser wall;

an opening in the diffuser wall adjacent the diffuser inlet; and,

a curved passageway adjacent the opening, wherein the curved passageway is curved convexly relative to the longitudinal axis, the curved passageway for introducing a secondary jet into the opening and along the diffuser wall for maintaining the secondary jet along the wall using the Coanda effect.

[c2] 2.The diffuser of claim 1 wherein an independent booster unit is connected to the curved passageway.

[c3] 3.The diffuser of claim 1 comprising a plurality of openings distributed about a circumference of the diffuser wall.

[c4] 4.The diffuser of claim 1 wherein fluid is further injected into the diffuser through an opening in a centerbody positioned within the diffuser.

[c5] 5.The diffuser of claim 3 wherein the plurality of openings are evenly distributed.

[c6] 6.The diffuser of claim 3 further comprising an annular manifold mounted around a circumference of an outer casing of the diffuser, the annular manifold collecting fluid from an outside source and distributing the fluid to the openings.

[c7] 7.The diffuser of claim 6 wherein fluid exiting the diffuser is transferred to the annular manifold.

[c8] 8.The diffuser of claim 6 wherein fluid from an independent booster unit is directed to the annular manifold.

[c9] 9.The diffuser of claim 1 wherein the opening is a circular opening having a diameter between 0.02W and 0.05W. .

[c10] 10.The diffuser of claim 1 wherein the opening is an annular slot having a height between 0.015W and 0.02W.

[c11] 11.The diffuser of claim 1 further comprising an airway directing air from an upstream turbine into the curved passageway.

[c12] 12.A gas turbine having a diffuser augmented with fluidic actuation, the gas turbine and diffuser comprising:
a diffuser inlet through which passes a main flow of air in a main flow direction;
a diverging section having a diffuser wall;
a centerbody placed within the diverging section;
at least one opening in the diffuser wall adjacent the diffuser inlet; and,
at least one opening in a wall of the centerbody in a vicinity of the diffuser inlet.

[c13] 13.The gas turbine of claim 12 further comprising an independent booster unit providing a secondary flow of fluid through the at least one opening in the diffuser wall.

[c14] 14.The gas turbine of claim 13 wherein passages are provided from the independent booster unit to each of the at least one opening.

[c15] 15.The gas turbine of claim 13 wherein the independent booster unit feeds air into an annular manifold surrounding the diffuser inlet, wherein the annular manifold distributes the air from the independent booster unit into the at least one opening.

[c16] 16.The gas turbine of claim 15 wherein a diameter of the annular manifold is at least 15 times greater than a diameter of each of the at least one opening.

[c17] 17.The gas turbine of claim 12 wherein each opening in the diffuser wall allows a secondary flow to pass, wherein each secondary flow is injected through an opening in the diffuser wall at a first controlled angle relative to the diffuser wall and at a second controlled angle relative to the main flow, wherein the first and second controlled angles are adjusted to maximize effectiveness.

[c18] 18.The gas turbine of claim 12 wherein the diffuser inlet has a width W and each opening in the diffuser wall is circular and has a diameter between 0.02W

and 0.05W.

[c19] 19.The gas turbine of claim 12 wherein the diffuser inlet has a width W and each opening in the centerbody is an annular slot having a height between 0.015W and 0.02W.

[c20] 20.The gas turbine of claim 12 further comprising a curved passageway adjoining each opening in the diffuser wall, wherein the curved passageway is curved convexly relative to the main flow direction.

[c21] 21.A gas turbine having a diffuser augmented with fluidic actuation, the diffuser comprising:
a diffuser inlet placed adjacent the turbine;
a diverging section having a diffuser wall;
an opening in the diffuser wall;
an exit port in the turbine, the exit port separate from a main turbine exit; and,
an airway extending from the exit port to the opening, wherein air is extracted from the turbine and introduced into the diverging section.

[c22] 22.The gas turbine of claim 21 wherein the airway extends from a final turbine stage.

[c23] 23.The gas turbine of claim 21 further comprising a plurality of airways extending from the turbine, and a plurality of openings in the diffuser wall.

[c24] 24.The gas turbine of claim 23 further comprising an annular manifold surrounding the diffuser inlet and the openings, the manifold collecting air from the airways and distributing the air to the openings.

[c25] 25.The gas turbine of claim 21 further comprising a plurality of ports in the turbine and an annular manifold collecting air from the ports via the airways for distributing to the openings.

[c26] 26.The gas turbine of claim 21 further comprising a curved passageway between the manifold and each of the openings, wherein the curved passageway is curved convexly relative to a longitudinal axis of the diverging section.

[c27] 27.The gas turbine of claim 21 wherein the airway is a tubular structure.

[c28] 28.A steam turbine comprising:

a final turbine stage;

an axial flow diffuser receiving a main flow from the final turbine stage;

a diverging wall in the axial flow diffuser, the diverging wall extending from a diffuser inlet to a diffuser exit;

a centerbody in the axial flow diffuser;

an opening in the diverging wall and an opening in the centerbody for fluidically actuating the main flow, wherein the openings are located downstream from the diffuser inlet and upstream from a point where boundary layer separation would occur along the walls in a diffuser without the openings.

[c29] 29.The steam turbine of claim 28 further comprising an independent booster unit positioned adjacent the diffuser for injecting a secondary flow into the axial flow diffuser.

[c30] 30.The steam turbine of claim 28 further comprising a suction source positioned adjacent the diffuser for sucking steam from the axial flow diffuser.

[c31] 31.The steam turbine of claim 30 further comprising a suction condenser supplied with cooling water at a lower temperature than cooling water of a main condenser of the steam turbine.

[c32] 32.The steam turbine of claim 31 wherein the lower temperature cooling water is the same cooling water used to supply the main condenser, and wherein the cooling water passes through the suction condenser prior to being sent to the main condenser.

[c33] 33.The steam turbine of claim 31 wherein a temperature difference between the cooling water supplied to the suction condenser and the cooling water supplied to the main condenser is less than approximately 10 ° F.

[c34] 34.The steam turbine of claim 28 wherein the diffuser inlet has a width W and the opening in the diverging wall is circular and has a diameter between 0.02W and 0.05W.

[c35] 35.The steam turbine of claim 28 wherein the diffuser inlet has a width W and the opening in the centerbody is an annular slot having a height between 0.015W and 0.02W.

[c36] 36.The steam turbine of claim 28 further comprising a plurality of openings in the diverging wall, each opening located equidistantly from the diffuser inlet.

[c37] 37.The steam turbine of claim 36 further comprising an annular manifold surrounding the plurality of openings in the diverging wall, the annular manifold collecting fluid from an outside source for distributing to the openings.

[c38] 38.The steam turbine of claim 37 further comprising tubes connecting the annular manifold to the openings.

[c39] 39.The steam turbine of claim 38 wherein the tubes are curved convexly relative to the main flow.

[c40] 40.The steam turbine of claim 37 wherein the annular manifold is at least 15 times greater in diameter than a diameter of each opening in the diverging wall.

[c41] 41.The steam turbine of claim 28 wherein steam is extracted from an upstream turbine stage for injection into the opening in the diverging wall.

[c42] 42.The steam turbine of claim 28 wherein steam is extracted from the diffuser exit and reinjected into the opening in the diverging wall.

[c43] 43.The steam turbine of claim 42 wherein steam is extracted from an upstream turbine stage and added to the steam extracted from the diffuser exit for increasing the total pressure of the injected fluid.

[c44]

44.A steam turbine comprising:
a final turbine stage;
a down-flow exhaust hood;
a centercone in the down-flow exhaust hood;
a steam guide passage in the down-flow exhaust hood receiving a main flow of air from the final turbine stage; and,
an opening in the steam guide for fluidically actuating the main flow, wherein

the opening is located downstream from the steam guide inlet and upstream from a point where boundary layer separation would occur along a steam guide without the opening.

[c45] 45.The steam turbine of claim 44 further comprising an independent booster unit positioned adjacent the exhaust hood for injecting fluid into the down-flow exhaust hood.

[c46] 46.The steam turbine of claim 44 further comprising a suction source positioned adjacent the exhaust hood for sucking steam from the down-flow exhaust hood.

[c47] 47.The steam turbine of claim 46 further comprising a suction condenser supplied with cooling water at a lower temperature than cooling water of a main condenser of the steam turbine.

[c48] 48.The steam turbine of claim 47 wherein the lower temperature cooling water is the same cooling water used to supply the main condenser, and wherein the cooling water passes through the suction condenser prior to being sent to the main condenser.

[c49] 49.The steam turbine of claim 47 wherein a temperature difference between the cooling water supplied to the suction condenser and the cooling water supplied to the main condenser is less than approximately $10\,^{\circ}$F.

[c50] 50.The steam turbine of claim 44 wherein the exhaust hood inlet has a width W and the opening is circular and has a diameter between 0.02W and 0.05W.

[c51] 51.The steam turbine of claim 44 wherein the exhaust hood inlet has a width W and the opening is an annular slot having a height between 0.015W and 0.02W.

[c52] 52.The steam turbine of claim 44 further comprising a plurality of openings in the steam guide, each opening located equidistantly from the exhaust hood inlet.

[c53] 53.The steam turbine of claim 52 further comprising an annular manifold surrounding the plurality of openings, the annular manifold collecting fluid from

an outside source for distributing to the openings.

[c54] 54.The steam turbine of claim 53 further comprising tubes connecting the annular manifold to the openings.

[c55] 55.The steam turbine of claim 54 wherein the tubes are curved convexly relative to the main flow.

[c56] 56.The steam turbine of claim 53 wherein the annular manifold is at least 15 times greater in diameter than a diameter of each opening.

[c57] 57.The steam turbine of claim 44 wherein steam is extracted from an upstream turbine stage for injection into the opening.

[c58] 58.The steam turbine of claim 44 wherein steam is extracted from the exhaust hood exit and reinjected into the opening.

[c59] 59.The steam turbine of claim 58 wherein steam is extracted from an upstream turbine stage and added to the steam extracted from the exhaust hood exit for increasing the total pressure of the injected fluid.

[c60] 60.A method of improving diffuser performance comprising:
allowing a main flow to pass through the diffuser;
providing an opening in a diffuser wall;
selecting a fluid source;
injecting fluid into the opening for preventing separation of the main flow from the diffuser wall; and,
directing the fluid at an angle relative to the main flow and relative to the diffuser wall which will maximize effectiveness.

[c61] 61.The method of claim 60 further comprising positioning a centerbody within the diffuser and providing an opening in a wall of the centerbody.

[c62] 62.The method of claim 61 further comprising injecting fluid through the opening of the centerbody and into the diffuser.

[c63] 63.The method of claim 60 wherein injecting fluid into the opening comprises injecting a pulsating jet of fluid.

[c64] 64.The method of claim 60 wherein injecting fluid into the opening comprises injecting a steady jet of fluid at constant pressure.

[c65] 65.The method of claim 60 wherein selecting a fluid source comprises selecting a source from the turbine upstream of the diffuser and plumbing the fluid from the source to the opening.

[c66] 66.The method of claim 60 wherein selecting a fluid source comprises connecting the output of an independent booster unit to the opening.

[c67] 67.The method of claim 60 wherein selecting a fluid source comprising redirecting fluid exiting the diffuser to the opening.

[c68] 68.The method of claim 60 wherein directing the fluid at an angle comprises sending the fluid through a curved passageway having a curvature which is convex relative to the main flow prior to injecting fluid into the opening.